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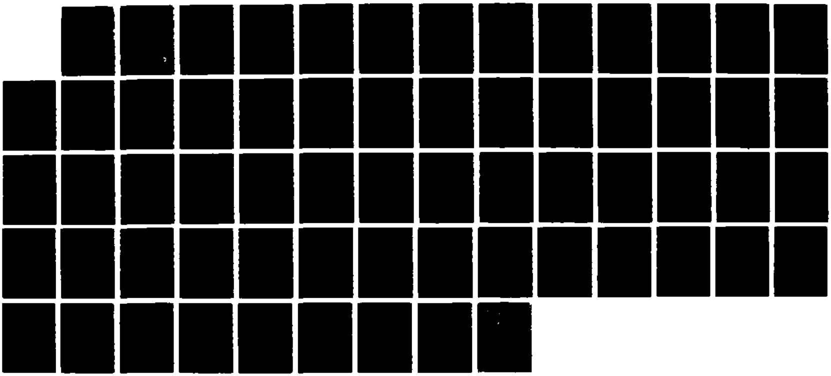

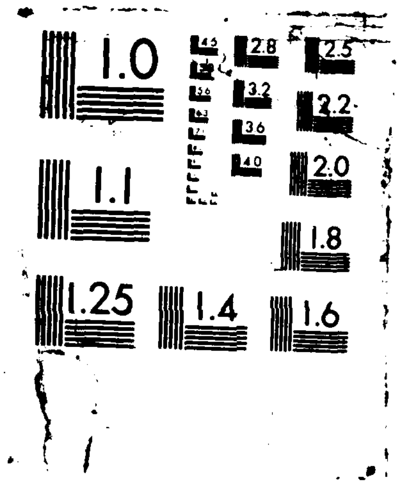
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COGNITIVE DECREMENT

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Technical Report

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The objective of this study was to review and select a taxonomy appropriate for the classification of Army helicopter crew tasks. The utility of such a taxonomy is that it provides a means for predicting performance of personnel on tasks which are similar to those already measured. This ability to generalize across tasks can save time and money in the process of predicting performance in a variety of jobs across numerous weapon systems. The study began with helicopter mission analysis followed by the identification of mission segments characterized by high operator workload. From these segments, tasks were defined and then classified.

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PREFACE

This report was prepared by the Human Performance Technology Division of Science Applications International Corporation (SAIC) for the Biomedical Effects Directorate of the Defense Nuclear Agency under contract number DNA 001-84-C-0290. The contract was monitored by Dr. Robert Young. The program manager was Dr. Michael L. Fineberg and the principal investigator was Dr. Joseph I. Peters.

The authors wish to express thanks to the many individuals who contributed to this effort. Dr. Robert Young provided continual support through his technical insight, patience and understanding of the challenges associated with large-scale data collection. Inputs from members of the Intermediate Dose Program aided significantly in early program definition. From the U.S. Army Nuclear and Chemical Agency, Captain James Davis proved instrumental in securing troop support through FORSCOM.

Of special note is the outstanding support provided by pilots of the U.S. Army. Major David Kellogg and personnel of the Combat Development Directorate at the U.S. Army Aviation Center, Ft. Rucker, Alabama, were invaluable in initial steps to defining high workload helicopter missions. Personnel of the 101st Airborne Division, Fort Campbell, Kentucky and Ft. Rucker, Alabama also provided extensive support through the entirety of this effort. We are particularly indebted to Mr. George E. LeFavor (CW4), Supervisor of the CH-47 Flight Simulator, who provided valuable insights into CH-47 operations.

Special thanks go to several members of the SAIC staff. Dr. Michael L. Fineberg, as the SAIC Program Manager, formulated the initial conceptual approach and fostered an environment for innovation and technical excellence to occur. Any shortcomings in that domain, however, are solely the responsibility of the authors. We are also greatly indebted to Dr. Eleanor Criswell for advice on task taxonomies and, to Ms. Brenda Frady for her expertise in graphics and report management.

The views expressed herein are solely the responsibility of the authors and are not to be taken as representing the position of the Defense Nuclear Agency, the U.S. Army or any other government agency.

CONVERSION TABLE

Conversion factors for U.S. Customary to metric (SI) units of measurement

MULTIPLY → / TO GET ←	BY → / BY ←	TO GET → / DIVIDE ←
angstrom	1.000 000 X E -10	meters (m)
atmosphere (normal)	1.013 25 X E +2	kilo pascal (kPa)
bar	1.000 000 X E +2	kilo pascal (kPa)
barn	1.000 000 X E -28	meter^2 (m^2)
British thermal unit (thermochemical)	1.054 350 X E +3	joule (J)
calorie (thermochemical)	4.184 000	joule (J)
cal (thermochemical)/cm^2	4.184 000 X E -2	mega joule/m^2 (MJ/m^2)
curie	3.700 000 X E +1	*giga becquerel (GBq)
degree (angle)	1.745 329 X E -2	radian (rad)
degree Fahrenheit	$t_K = (t°f + 459.67)/1.8$	degree kelvin (K)
electron volt	1.602 19 X E -19	joule (J)
erg	1.000 000 X E -7	joule (J)
erg/second	1.000 000 X E -7	watt (W)
foot	3.048 000 X E -1	meter (m)
foot-pound-force	1.355 818	joule (J)
gallon (U.S. liquid)	3.785 412 X E -3	meter^3 (m^3)
inch	2.540 000 X E -2	meter (m)
jerk	1.000 000 X E +9	joule (J)
joule/kilogram (J/kg) (radiation dose absorbed)	1.000 000	Gray (Gy)
kilotons	4.183	terajoules
kip (1000 lbf)	4.448 222 X E +3	newton (N)
kip/inch^2 (ksi)	6.894 757 X E +3	kilo pascal (kPa)
ktap	1.000 000 X E +2	newton-second/m^2 (N-s/m^2)
micron	1.000 000 X E -6	meter (m)
mil	2.540 000 X E -5	meter (m)
mile (international)	1.609 344 X E +3	meter (m)
ounce	2.834 952 X E -2	kilogram (kg)
pound-force (lbs avoirdupois)	4.448 222	newton (N)
pound-force inch	1.129 848 X E -1	newton-meter (N·m)
pound-force/inch	1.751 268 X E +2	newton/meter (N/m)
pound-force/foot^2	4.788 026 X E -2	kilo pascal (kPa)
pound-force/inch^2 (psi)	6.894 757	kilo pascal (kPa)
pound-mass (lbm avoirdupois)	4.535 924 X E -1	kilogram (kg)
pound-mass-foot^2 (moment of inertia)	4.214 011 X E -2	kilogram-meter^2 (kg·m^2)
pound-mass/foot^3	1.601 846 X E +1	kilogram/meter^3 (kg/m^3)
rad (radiation dose absorbed)	1.000 000 X E -2	**Gray (Gy)
roentgen	2.579 760 X E -4	coulomb/kilogram (C/kg)
shake	1.000 000 X E -8	second (s)
slug	1.459 390 X E +1	kilogram (kg)
torr (mm Hg, 0° C)	1.333 22 X E -1	kilo pascal (kPa)

*The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s
**The Gray (Gy) is the SI unit of absorbed radiation.

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SECTION 1

INTRODUCTION

1.1 STATEMENT OF PROBLEM.

The Defense Nuclear Agency needs to know how performance of Army helicopter crew members is affected by exposure to intermediate doses of nuclear radiation. Obvious moral and ethical considerations preclude exposure of humans to radiation, and animal studies preclude insight into the effects of such radiation on human cognition. The problem then, is how to predict the cognitive performance decrement of Army aircrews in a fashion which is accurate and reliable and, at the same time, free of undue hazards to such crews.

To tackle the problems of radiation induced performance decrement, the Defense Nuclear Agency sponsored a tri-service effort entitled the "Intermediate Dose Program" (IDP). As such, members of the IDP core working group adopted the use of crew estimates of task time degradation as a measure of performance effectiveness. The techniques for addressing how symptoms are identified and related to performance are discussed in depth in other reports (Peters, et al., 1985 and Glickman et al., 1983).

1.2 TASK DEFINITION PROCESS.

The basic unit of human peformance measurement used in the Intermediate Dose Program is the task. Examples of tasks analyzed in prior studies are:

- Designate azimuth and target,
- From standstill, drive forward 40 feet and stop,
- Reload,
- Command driver to firing position.

These tasks ranged in nominal time from about two seconds to one minute.

The objective of the current study was to focus in on the performance of helicopter crews. Tasks measured in prior studies (tanks, Howitzers, etc.) focused largely on the firing of weapons and lacked the

degree of cognitive and precise physical coordination which is required of helicopter crews. As a result, particular interest was expressed by the Defense Nuclear Agency (DNA) in assessing the impact of radiation on the high level of cognitive and precise visual-motor skills of helicopter pilots.

More specifically, the DNA expressed special interest in an analysis of helicopter crew performance in an attack mission. Attack helicopters were preferred primarily because, although the flying task was different, they shared many tasks which were in common with those analyzed in most prior studies, i.e., arming, aiming and firing of a weapon.

An analysis of the attack helicopter missions of interest highlighted several points which made helicopters considerably more difficult to study than ground-based systems. These points included the following:

- Helicopters have more operational degrees of freedom
- Continuous control versus discrete tasks predominate
- Crew size is generally smaller
- Confined on-board space precludes in-flight observation of tasks

A brief discussion of each of the above points follows.

The fact that helicopters operate in three dimensional space significantly complicates the accuracy and reliability of measurements of system performance. The fact that pilots are always flying the helicopter as long as it is airborne makes it very hard to define the beginning and ending points of tasks. Because there are two pilots on board with their hands and feet almost continuously on the controls, it becomes impossible to differentiate the flying tasks of one pilot versus those of the other unless the observers interfere with the pilot's natural procedures. In an effort not to interfere with in-flight procedures, all tasks measured in this study rendered task times for each "crew". Therefore, separate times for pilot vs. copilot duties were not measured for the particular tasks observed in this study.

Perhaps the biggest constraint in performing a task timeline analysis of an attack helicopter crew was the fact that it is impossible to fit an observer with a stopwatch into the helicopter. There is not enough room! An attractive and still viable alternative, however, was the use of a high-fidelity helicopter simulator where there is enough room for an observer. Increased capacity of a simulator to hold more people was but only one, albeit major, advantage. Section 3 of this study discusses the other advantages and some disadvantages.

One major disadvantage of having to rely on a simulator for observation of tasks is the limited number, if any, of those available - especially for such purposes as task timeline analysis of high workload tasks. Due to the uncertainty in availability of simulators, the study approach taken was to perform a mission analysis which was both unconstrained by the availability of hardware and yet identified enough mission segments of interest, that a high probability of success in measuring at least one aircraft would be achieved.

In summary, the process leading to task definition involved several steps. They were:

1. Mission Analysis
2. Mission Segment Identification
3. Task Definition
4. Task Classification

These steps are reported in the sections to follow.

SECTION 2

MISSION ANALYSIS

The mission analysis phase of this study involved visiting with operational helicopter crews and reviewing literature pertinent to helicopter operations. Numerous field manuals, training circulars and technical manuals (See Reference Section) were consulted for the latest available information on the operational environment. From these sources, four separate mission were identified:

- Attack
- Observation
- Utility
- Transport

The attack mission is currently peformed primarily by two helicopters, the AH-1 "Cobra" and the AH-64 "Apache". Observation and scouting are performed by the OH-58 "Kiowa". The utility mission is performed by the UH-1 "Huey" and the UH-60 "Blackhawk" helicopters, and the transport mission is peformed primarily by the CH-47 "Chinook".

Given DNA's interest in the attack mission and an increasing knowledge of the availability of CH-47 simulators, scenarios were written for both the Attack and the Transport missions. These scenarios served as an initial baseline or "straw men" for presentation to operational pilots at Ft. Rucker, Alabama and Ft. Campbell, Kentucky. These pilots commented on the authenticity of the scenarios, assisted in refining them and contributed to the identification of high workload mission segments. Copies of the scenarios are reproduced in Appendix A.

SECTION 3

MISSION SEGMENT IDENTIFICATION

Although the primary missions of Army helicopters is rather clear, an analysis shows that when missions are broken down into segments, all aircraft share some common functions. Table 1 portrays those mission segments performed by aircraft under the four mission specialty areas.

The general attack mission scenario developed in Section 2 (Appendix A) was biased toward a Cobra helicopter mission; however, to increase flexibility in being able to collect task and task timeline data, separate scenarios were developed for several mission segments. Some of the scenarios were robust enough to apply to more than one aircraft. These scenarios are provided in Appendix B.

A brief discussion of each segment in Table 1 and the related crew skills, knowledges and abilities required for each segment follows:

<u>Take-Off and Hover Check</u>. *This a highly proceduralized segment of* the missions of all aircraft. It requires sophisticated eye-hand coordination refined by means of intensive training. In addition, it requires a thorough knowledge of how the engine and transmission function. Pilots are required to know which parameters to check on their instrument panels and the tolerance levels for safe and acceptable operation before making a decision to proceed in the flight regime.

<u>Sling Load Pick-Up</u>. This mission segment applies to only those aircraft equipped with hardware for attaching lines to cargo for hauling by means of a sling hanging beneath the helicopter. To peform this mission segment, pilots are required to have good eye-hand coordination, stamina and good crew coordination. Eye-hand coordination supplemented by good depth perception is required to control the aircraft within fine constraints defined by cargo size, shape and location on the terrain. Stamina is required to some degree in order to maintain position of the helicopter in a relatively stable position while compensating for the effects of wind. Crew coordination is especially required in the CH-47 where

Table 1. Mission segments of various Army helicopters.

Mission Type / Mission Segments	Attack (AH-1)	Transport Observation (CH-47)	Utility (UH-1) (UH-60)	Observation (OH-58)
Take Off & Hover Check	X	X	X	X
Sling Load Pick-Up		X	X	
NOE/Contour Navigation	X	X	X	X
Fire Suppression	X			
Sling Load Drop-Off		X	X	
Target Handoff	X			X
Pop-Up and Tow Launch	X			
Evade Threat	X	X	X	X
Perform Emergency Procedures	X	X	X	X
Land Aircraft	X	X	X	X

the cargo to be picked up cannot be seen by the pilot. Coordinatioon between the pilot and flight engineer therefore is esential and takes the nature of brief height and altitude directions from the engineer such as "Up 2 feet, Left 2, Down 1", etc. in response to pilot adjustments.

<u>NOE Navigation</u>. Nap-of-the-earth (NOE) navigation involves both map reading and crew coordination skills. NOE flight is the type of flight which occurs at or below tree-top level and takes maximum advantage of the concealment provided by the local greenery and terrain. It is characterized by slow, often stop-and-go movement. Contour flight, on the other hand, is characterized by continuous movement but with emphasis on lowest possible altitude. NOE flight is quite typical of Scout, Attack and Utility missions; however, Transport missions due to CH-47 system dynamics and size, typically go only as low as contour flight allows.

As the altitude of flight missions decreases, there is increased dependency on the skills of the crew in map reading. This is true because the lower altitudes deny the crew of the same broad perspective from which their map was created. Therefore, the numbers of cues become less and the crew is more dependent on mental imagery of their location based on contour lines in the map and map-terrain associative skills.

The need for good crew coordination is emphasized in NOE navigation tasks. This is largely true because the workload involved with keeping the helicopter from hitting obstacles precludes the pilot from looking at a map. The co-pilot, therefore, is continually comparing his perceived position on the map with his actual position and simultaneously issuing instructions to the pilot.

<u>Fire Suppression</u>. Fire suppression is the employment of weapons to suppress enemy fire. The best equipped for this segment is the Attack helicopter because of the versatility of weapons aboard, its firepower and the fact that it was designed for the purpose of enemy engagement. Other aircraft, however, can and do perform fire suppression. The UH-1 can be equipped with rockets and guns for fire suppression.

Overall, Utility and Attack aircraft are the primary aircraft performing fire suppression. However, anyone carrying a rifle or machine gun on any helicopter can perform fire suppression. The distinction is that between "mission" versus "activity". Therefore, Table 1 designates Attack and Utility helicopters as having a fire suppression mission even though other aircraft may do fire suppression when they have to.

The skills associated with fire suppression are largely eye-hand coordination. These are associated with aiming and firing the weapon while siumultaneously flying the aircraft.

Sling Load Drop-Off. The characteristics of sling load drop-off are very similar to those for picking up a sling load. The only noticeable difference is that, for obvious reasons, the accuracy of placement is usually not as critical as that for pick-up. Associated eye-hand and crew coordination requirements therefore are also slightly less stringent.

Target Handoff. Target handoff involves the sighting of a target, conversion of target location into communicable coordinates and the follow-through communicatin of target location either to another aircraft or ground based communications mode. This activity is usually peformed by attack or observation aircraft. Requirements for target handoff are target detection ability, map-terrain associative skills, map reading abilities to convert map location into coordinates, short-term memory, good articulation and proper communications procedures.

Pop-Up and Tow Launch. This mission segment is unique to attack helicopters. Performance of a pop-up and TOW launch maneuver involves a sudden rise in altitude from a concealed position, location of target and considerable crew coordination in aiming, firing and tracking a wire-guided missile into the target. Tasks associated with executing this maneuver require considerable knowledge of proceduralized steps for weapon selection, arming, aiming and firing. Crew coordination is essential for hitting the target. Both pilot and gunner require good eye-hand coordination

as they maintain the aircraft and missile respectively, within constraints.

Evade Threat. Being able to evade a threat system is paramount to the survivability of any helicopter. It involves either visually detecting a tank or SAM site through the helicopter windscreen or receiving an audio or visual warning that enemy radar is scanning your aircraft. The appropriate response for evading a threat is to break visual and radar contact as quickly as possible. This usually occurs by means of a combination of driving and turning maneuvers. The major characteristic of this situation is uncertainty and is handled best through abilities of crews to react quickly and safely while maintaining their orientation.

Perform Emergency Procedures. As the title suggests, this type of activity is highly proceduralized and is associated with a well trained set of responses. As in "evading threat", the uncertainty factor is very high here, and likewise, the desirable crew characteristic is speed and accuracy of response. Because the population of possible system emergencies and associated responses is limited, the use of well trained standard procedures has been the traditional method for handling them. In that vein, the amount of uncertainty to be reduced for a system-related emergency is potentially far less than in a threat evasion situation in which an unknown or little-known threat is encountered. Therefore, a pilot's consistency in following procedures is a more desirable characteristic for handling system emergencies, and proficient flying skills become more desirable for handling evasion of threats.

Land Aircraft. The pilot skills associated with landing a helicopter are similar to those for dropping off a sling load. Good eye-hand coordination and depth perception is paramount. Some dependency on established procedures exists, and some crew coordination may be required, especially for the larger aircraft such as the CH-47.

SECTION 4

TASK DEFINITION

4.1 AH-1 TASKS.

The initial Cobra task analyses were peformed by 13 helicopter pilots from Fort Rucker, Alabama. Six of the pilots were from a FORSCOM attack helicopter company; the seven others had previous operational experience and were assigned at the time to TRADOC's Combat Development Center. Their operational experience is summarized as follows:

- 7 - Attack Pilots/Gunners (AH-1 "Cobra")
- 5 - Observation Pilots (OH-58 "Scout," O-2)
  - 3 - Armor
  - 2 - Artillery
- 1 - Utility Pilot (UH-1, "Huey")

Each of the pilots was given those scenarios in Appendix B which were appropriate for his particular aircraft. Deficiencies in the scenarios were refined accordingly.

Pilots were taught the basics of task identification with the objective being the ability to time each task. Emphasis therefore was placed on identifying discrete, observable start and stop points as anchors for later timeline analysis. Emphasis was also placed on ensuring tasks were defined at the "micro" level. For example, pilots were told that "starting the engine" did not comprise a sufficient breakdown of the activity and that there were discrete and observable actions which comprised steps in starting the engine. Their task was to define these steps. The AH-1 technical manual (TM 55-1520-236-10) was provided as an aid to the Cobra pilots in helping them to remember some of the tasks, particularly in the "Takeoff and Maintain Hover" mission segment, where the checklist formalizes many of the steps.

The individual pilot accounts of each of the mission segments were compared for consistency, and inconsistencies were resolved through majority rule. In a few cases, phone calls were made to some pilots to clarify certain points. Appendix C includes the results of integrating pilot

accounts of three mission segments of interest for the Cobra attack helicopters.

4.2 CH-47 TASKS.

The CH-47 task analysis was quite revealing with regard to differences in aircraft mission. The weapons-related tasks of the Cobra were, as expected, very similar to the firing of ground-based weapons. As such, they were discrete as opposed to continuous tasks and thus amenable to short-term, fairly reliable timing procedures which could be applied against each crew position. Tasks analyzed for the CH-47, however, were fundamentally based in the "flying" aspects of the tasks. The start and stop times of such tasks were therefore anchored more on system observables versus crew behaviors. This resulted in generally longer tasks which did not differentiate separate crew member roles.

The basis for CH-47 task analysis was repeated observations of pilots in the CH-47 simulator. These observations were converted into lists of tasks which were then discussed with several CH-47 pilots. Task definitions were then modified based on pilot inputs. When a proposed scenario for task-timeline data collection was presented, tasks were further refined with inputs from two seasoned CH-47 simulator operators/instructor pilots.

SECTION 5

COGNITIVE TASK TAXONOMY

The study by Glickman et al. (1983) demonstrated that the estimated effects of symptom complexes were fairly generalized across tasks. There was one exception in which estimated symptom effects exagerated the decrement of those crew members performing physically demanding tasks. From this, one might hypothesize that physically demanding tasks in general are more vulnerable to the effect of low dose nuclear radiation than are less physically demanding tasks. This section discusses the need for taxonomy, reviews the current literature and applies a taxonomy to several helicopter tasks.

5.1 THE NEED FOR A TAXONOMY.

One limitation in the methodology employed by the Intermediate Dose Program is that there is currently no method for systematically generalizing radiation effects on one task to those on similar tasks in other hardware systems. A system therefore is needed which will provide a classification of tasks, including aspects such as physical demand, so that when empirical data are available for one member of the class, accurate generalizations can be made to all tasks belonging to the same classification.

A major reason for DNA's attention to helicopter crew performance analysis is the concern over the potential for increased vulnerability of aircrews to radiation sickness. This concern is based on the perception that there are more workload demands on helicopter pilots than on ground crews and that the nature of the workload is more oriented to tasks involving cognitive processes rather than sensation or physical strength requirements. As such, emphasis in the development of a taxonomy was initially placed on discriminating among various cognitive functions such as long and short term memory, attention, and information coding and processing.

5.2 REVIEW OF THE LITERATURE.

The seminal document on the topic of taxonomies of human tasks is a recent book by Fleishman and Quaintance (1984). Although numerous taxono-

mies and variants are discussed, it appears that there are three basic and distinguishable approaches to classifying tasks:

- Behavior Description
- Behavior Requirements
- Ability Requirements
- Task Characteristics

These approaches are the best developed taxonomies with an already substantive body of studies which support, in varying degree, the reliability and validity of their tenets. A brief discussion of each follows.

5.2.1 Behavioral Description.

This form of classification is based solely on overt behaviors of the person performing a task. As such, the taxonomy is insensitive to why a particular action is occurring and focuses on quantitative measurement of the task. The overall strength of this approach is that it is comprehensive in describing activities. The weakness of the approach however is that because it is so comprehensive of behaviors it la ks meaningful discriminability across tasks.

5.2.2 Behavior Requirements Approach.

The behavior requirements approach goes a step beyond observed behavior only and introspects the requirements for successful performance. This approach might have appeal to the development of a cognitive task taxonomy in that many cognitive processes are seen as requirements for tasks (i.e. memory, decision-making, etc.). As is the drawback for the field of cognitive psychology, however, the behavioral requirements approach falls short in its ability to quantify the behavior being required.

5.2.3 Ability Requirements Approach.

Unlike the behavioral descriptive approach, the ability requirements approach can discriminate among tasks based upon the abilities that they require of the person performing them. As such, this approach works well in a factor analytic environment where the person defining abilities is

also exercising the taxonomy. Use of the ability requirements approach usually lacks objectivity in the definition of tasks and thus reliability across classifiers suffers. This approch would appear to be useful in manpower modeling activities.

5.2.4 Task Characteristics Approach.

This approach attempts to divorce itself from introspective techniques of projecting what human requirements or abilities are demanded by the task. Instead it focuses largely on the stimuli which characterize the environment in which the task is performed and the task responses which affect the environment. This approach appears the most promising for one interested in high inter-rater reliability and the ability to generalize to equivalent types of tasks. This approach is unique in that it is not dependent upon human abilities or requirements to classify tasks.

5.3 TAXONOMY APPLIED TO HELICOPTER TASKS.

Of the four basic types of taxonomies discussed, two are particularly attractive for application to military weapon system tasks. The Behavioral Requirements approach appears to be the one most appropriate for defining categories of cognitive activities; however, as mentioned in the preceding sections, its biggest drawback is an inability to be quantitative. The task characteristic approach, on the other hand, appeared to be more measurement oriented with an objective method of rating tasks. A complete set of scales has already been developed including those which assess decision making, workload and degree of muscular effort.

Because these scales appear to address those factors which have demonstrated at least some task discrimination in prior studies and because on overriding concern was the ability to generalize from one military task to another, the task characteristic approach was selected for further study.

5.4 APPLICATION OF THE TASK CHARACTERISTIC APPROACH TO HELICOPTER TASKS.

Scales provided by Fleishman and Quaintance (1984) were used independently by two raters to evaluate the helicopter tasks listed in Table 1, of the preceding section. Each rater filled out 21 scales evaluating

each of the 13 tasks listed. Each of the 21 scales had a rating range from 1 to 7. Table 2 is a blank version of the matrix required to be filled out by each rater and Appendix D includes the filled in matrices along with an example of a scale from Fleishman and Quaintance.

An analysis of agreement between raters was conducted using the standard formula:

$$\frac{\#\ \text{Agreements}}{\#\ \text{Ratings}}$$

An agreement was taken to mean that the distance between the two ratings was less than or equal to 2. Thus if one rater scores a "4", an agreement would be scored if the other rater's score was 2, 3, 4, 5, or 6. Exact matches accounted for about 1/3 of the agreements. Given the degree of subjectivity involved in using the rating scales, this definition of agreement was acceptable for our purposes.

Results of the inter-rater agreement analysis are presented in Table 3. The scores appear to cluster together with the exception of only two tasks: engine fire and cargo hookup. There, scores suggest that the nature of the task did not affect the difficulty in using the scales. The results do show, however that application of some scales was more difficult than others. Further analysis revealed that agreement scores were under .70 for 10 of the 21 scales. It might have been the case that raters had trouble applying those scales to any task.

It may be desirable to use these scales in the future as the basis for a generalization model. As mentioned earlier, these scales have been validated in other work. If the scales are used in the future, however, one of two general approaches should be taken. One, raters might undergo more extensive training in the application of the scales, or two, the raters could discuss all ratings, arrive at a consensus, and use the consensus figure as the value in the generalization model. This second approach appears warranted for future efforts.

Table 2. Task characteristic ratings applied to U.S. Army helicopter missions.

TASKS \ RATING SCALES	NUMBER OF OUTPUT UNITS	DURATION OUTPUT UNIT MAINTAINED	NUMBER OF ELEMENTS PER OUTPUT UNIT	WORKLOAD	DIFFICULTY OF GOAL ATTAINMENT	PRECISION OF RESPONSES	RESPONSE RATE	SIMULTANEITY OF RESPONSES	DEGREE OF MUSCULAR EFFORT INVOLVED	NUMBER OF PROCEDURAL STEPS	DEPENDENCY OF PROCEDURAL STEPS	ADHERENCE TO PROCEDURES	PROCEDURAL COMPLEXITY	VARIABILITY OF STIMULUS LOCATION	STIMULUS OR STIMULUS COMPLEX DURATION	REGULARITY OF STIMULUS OCCURRENCE	OPERATOR CONTROL OF THE STIMULUS	OPERATOR CONTROL OF THE RESPONSE	REACTION TIME/FEEDBACK LAG RELATIONSHIP	FEEDBACK	DECISION MAKING
TAKE-OFF TO HOVER																					
HOVER POWER CHECK																					
CARGO HOOK-UP																					
DEPART WITH CARGO																					
CARGO DROP-OFF																					
DEPART																					
LOW-LEVEL NAVIGATION																					
EVADE THREAT																					
ENGINE FIRE																					
FIRE SUPPRESSION																					
TARGET HAND-OFF																					
POP-UP & TOW LAUNCH																					
RUNNING LANDING																					

Table 3. Inter-rater agreement analysis.

Tasks	Agreement
Take off to Hover	.71
Hover Power Check	.76
Cargo Hook-Up	.62
Depart with Cargo	.76
Cargo Drop-Off	.76
Depart	.71
Low Level Navigation	.67
Evade Threat	.71
Engine Fire	.52
Fire Suppression	.76
Target Hand-Off	.81
Pop-Up and Tow Launch	.81
Running Landing	.81

SECTION 6

LIST OF REFERENCES

1. Fleishman, E.A. and Quaintance, Marilyn K. Taxonomies of human performance: The description of human tasks. Orlando, FLA: Academic Press, 1984.

2. Glickman, A.S., Winne, P.S., and Moe, R.B. Estimated effects of intermediate levels of nuclear radiation upon the performance of military tasks: a questionnaire assessment (ORG Technical Report 82-2/3-1 (Draft)). Norfolk, VA, Organization Research Group of Tidewater, Inc., March 1983.

3. Peters, J.I., Archer, M.A., and Moyer, M.A. Cognitive performance decrement in U.S. Army aircrews (SAIC Technical Report: SAIC-85/1787). McLean, VA, Science Applications International Corporation, August 1985.

Field Manuals

4 FM 100-5 Operations, 20 August 1982.

5. FM 17-50 Attack Helicopter Operations, 1 July 1977.

6. FM 1-203 Fundamentals of Flight, 9 September 1983.

7. FM 1-5 Instrument Flying and Navigation for Army Aviators, 7 July 1980.

Training Circulars

8. TC 1-4 Helicopter Gunnery, 30 September 1976.

9. TC 1-60 Forward Area Refueling and Rearming Point Operations, 20 February 1979.

10. TC 1-30 Preparation of the AH-1 for Night Flight, 30 September 1976.

11. TC 1-31 Preparation of the OH-58 for Night Flight, 28 February 1977.

12. TC 1-32 Preparation of the CH-47 for Night Flight, 30 June 1977.

13. TC 1-136 Aircrew Training Manual, Attack Helicopter, 16 January 1981.

14. TC 1-137 Aircrew Training Manual, Observation Helicopter, 27 July 1982.

15. TC 1-137 Aircrew Training Manual, Cargo Helicopter, 27 July 1982.

16. Flight Training Supplement to TC 1-136 for AH-1s Aviation Qualification Course United States Army Aviation Center, Fort Rucker, Alabama, August 1983.

17. Flight Training Supplement to TC 1-137 for OH-58 Transition and Aeroscout Combat Skills, U.S. Army Aviation Center, Fort Rucker, Alabama, October 1983.

18. Flight Training Supplement to TC 1-139 for CH-47 Aviation Qualification Course. U.S. Army Aviation Center, Fort Rucker, Alabama, June 1983.

Technical Manuals

19. TM 55-1520-227-10-2
Operator's Manual Army Model CH-47C Helicopter, 29 May 1984.

20. TM 55-1520-227-CL-2
Operator's and Crewmember's Checklist, Army Model CH-47C Helicopter, 29 May 1984.

21. TM 55-1520-240-10
Operator's Manual, Army CH-47D Helicopter, 10 November 1982.

22. TM 55-6930-212-10
Operator's Manual for CH-47C Flight Simulator (CH-47FS), 1 February 1983.

23. TM 55-1520-236-10
Operator's Manual: Army Model AH-1s (PROD) (ECAS) (MOD) Helicopters, 11 January 1980.

24. TM 55-1520-236-CL
Operator and Crewmember Checklist: Army Model AH-1s (PROD) (ECAS) (MOD) Helicopters, 3 January 1980.

APPENDIX A

ATTACK AND TRANSPORT MISSION SCENARIOS

A.1 ATTACK MISSION SCENARIO.

As evening approaches, an armored enemy force has penetrated friendly defenses and is gradually gaining momentum. Friendly Air Cavalry units have been able to determine the extent of the force, make initial contact and have been in touch with friendly ground elements. An attack helicopter battalion has been assigned the task of attacking the flank of the enemy force.

During flight planning and preflight tasks, the required MOPP gear in conjunction with the heat of the day makes the pilots uncomfortable. Aircraft of the attack company perform their hovering tasks and then proceed with a normal takeoff. The unit, using the traveling technique of movement, moves forward to the holding area leaving the forward assembly area behind. At the holding area, the attack helicopters coordinate with the aeroscouts and by platoons, using traveling and bounding overwatch techniques, move out to the battle positions and receive target hand offs.

From firing positions, the cobras partially unmask themselves and acquire their targets. Then, the AH-1s unmask as required to fire, engaging the enemy T-62s and BMPs, then quickly remasking and shifting to alternate firing positions to deter the efforts of the ZSU-23-4s. This process of engagement is repeated several times adding to the number of burning vehicles resulting in a smoke screen that threatens to obscure the battle area.

The road, now clogged with wrecked vehicles is blocking the lead elements of the advance as the force attempts to reform and continue the operation. The enemy commander, not easily put off by these set backs, initiates a flanking movement which is quickly discovered by cavalry. In need of fire power, aeroscouts direct one platoon of the cobras from their battle positions to counter the flanking maneuver. The AH-1s again set into firing positions then using their guns, assist friendly artillery in providing suppressive fire at BMPs and dismounted infantry threatening to overrun a friendly ground element.

Having expended their munitions, the cobra platoon retires from the battle area flying nap-of-the-earth. It is after sunset, requiring the crews to use night vision goggles. Enroute to the holding area, a small enemy ground element is discovered and a cobra pilot transmits a spot report. Using the appropriate techniques of movement along the avenues of approach, the platoon returns to the forward area rearm/refuel point to begin preparations for the next mission.

A.2 TRANSPORT MISSION SCENARIOS.

In this portion of the study, we will record times for the successful completion of individual tasks performed during missions by crew members who are healthy. To do this, time data will be collected from missions that have been previously defined for this sutdy. It is essential that you fly the mission, along the planned route so different crews' performances can be compared. All crews will fly the same missions.

Each mission starts at the end of the runway with engines running. You will then proceed to pick up a high density 18,000 lb. sling-load located halfway down the runway. Using contour flying techniques and traveling as quickly as possible, fly the preplanned route as indicated on the map. The air check points (ACP) along the enroute portion of the mission are to be identified. Upon reaching the destination, you will deliver the cargo and go back to the airfield via the return route.

FLIGHT MISSION TO CONFINED AREA 5

CONDITIONS

CONDITION Daylight

VISIBILITY 1 mile

CEILING 500 ft.

TEMPERATURE +15 °C

ALTIMETER 2992

WINDS

DEPARTURE WD/WV 020/20

CARGO DESTINATION WD/WV 330/20

LANDING APPROACH WD/WV 220/20

TURBULENCE Moderate for Entire Route

AIRFIELD LOCATION Campbell AAF

CARGO 18,000 lbs. High Density Sling-Load

DESTINATION Confined Area 5

ALTITUDE RESTRICTIONS Below 300 ft. AGL

NOTE:

- Due to ground tactical plan, you must adhere to the preplanned route.
- Every effort must be made to accomplish the mission as quickly as possible.
- Numerous spot reports have been made of enemy activity to the south of confined area 5.
- Aircraft configured to just under 46,000 lbs.

DESCRIPTION:

- Without drifting, takeoff and maintain a hover (ALPHA).
- Perform a hover power check announcing check items.
- Proceed to and pick up 18,000 lb. high density sling-load near center of the runway (BRAVO).
- While maintaining position, perform a hover power check.

FLIGHT MISSION TO CONFINED AREA 5

- Using contour flying techniques (below 300 ft. AGL), fly the preplanned route drawn on the map. Announce when you think you have reached each of the following ACPs:

    - BRIDGE - (CHARLIE)
    - BRIDGE - (DELTA)
    - BUILDING - (ECHO)
    - BRIDGE - (FOXTROT)
    - BRIDGE - (GOLF)

- At ACP GOLF, turn left and proceed along the route to confined area 5 (Hotel). Announce when you have identified confined area 5.

- Deliver cargo to confined area 5 (Hotel).

- Continuing to use contour flying techniques (below 300 ft. AGL) quickly return to the airfield along the preplanned route. Identify and announce reaching ACP INDIA.

- Make a running approach to the airfield.

- Final task is the front wheels touching down on the runway.

FLIGHT MISSION TO CONFINED AREA 7

CONDITIONS

CONDITION Daylight

VISIBILITY 1/2 mile

CEILING 500 ft.

TEMPERATURE +15 ^{o}C

ALTIMETER 2992

WINDS

DEPARTURE WD/WV 020/20

CARGO DESTINATION WD/WV 330/20

LANDING APPROACH WD/WV 220/20

AIRFIELD LOCATION Campbell AAF

CARGO 18,000 lbs. High Density Load (Sling)

DESTINATION Confined Area 7

ALTITUDE RESTRICTIONS Below 300 ft.

NOTE:

- Due to the ground tactical plan, you must adhere to the preplanned route.
- Every effort must be made to accomplish this mission as quickly as possible.
- Aircraft is configured to just under 46,000 lbs.

DESCRIPTION:

- Takeoff to a hover and maintain position (ALPHA).
- Perform a hover (power) check announcing checklist items.
- Proceed to and pick up 18,000 lb. high density sling-load near center of the runway (BRAVO).
- Perform another hover (power) check announcing check items.
- Using contour flying techniques (below 300 ft. AGL) fly the preplanned route on the map to confined area 7.
- Announce identification of confined area 7 and deliver the sling-load.
- Following the route indicated, depart confined area 7, resume contour flying and return to airfield making a running approach.

FLIGHT MISSION TO CONFINED AREA 7

- Final task is the front wheels touching down on the runway.

APPENDIX B

MISSION SEGMENT SCENARIOS

Mission: Attack, Observation or Utility

Mission Segment: Takeoff and Maintain Hover

Helicopters: AH-1s, OH-58, UH-1

Scenario: It is early morning. Your aircraft is ready to go. It has undergone a pre-dawn health indicator test and the throttle has been pre-set. You are about to go through engine start-up procedures using asterisked items on the check-list.

Mission: Attack

Mission Segment: Fire Suppression

Helicopter: AH-1s

Scenario: You are the second of a two-ship attack formation. Lead ship is directly in front of you as you use traveling overwatch as the planned technique of movement. It is a hot day and you, as pilot, are traveling under visual meteorological conditions (VMC). You detect tracers from ground fire directed to lead ship's 7 o'clock. Your only available armament is guns and the situation calls for helmet sight hand-off to the gunner.

<u>Mission</u>: Attack

<u>Mission Segment</u>: Pop-up and TOW Launch

<u>Helicopter</u>: AH-1s

<u>Scenario</u>: It is a hot day and you are masked in a good firing position. You are under VMC/VFR conditions and are awaiting target handoff from the Scout. You have good local security.

<u>Mission</u>: Observation

<u>Mission Segment</u>: Target Handoff

<u>Helicopter</u>: OH-58

<u>Scenario</u>: It is a hot day and you are a Scout pilot traveling under VMC/VFR conditions. Your Cobra is concealed in firing position and you are moving forward in an NOE environment. You are using lateral masking until you contact the enemy.

Mission: Utility

Mission Segment: Landing Approach

Helicopter: UH-1

Scenario: You are returning from a night, NOE transport mission. You have a full load of troops and are entering the landing approach phase.

APPENDIX C

COBRA TASK ANALYSES

Mission: Attack

Mission Segment: Takeoff and Maintain Hover

Helicopter: AH-1s (ECAS)

TASK	GUNNER SAYS:	PILOT	TIME
1.	"BATTERY SWITCH START"	TURNS ON BAT SWITCH AND SAYS "ON"	
2.	"VOLTMETER CHECK"	PILOT LOOKS AT VOLTMETER AND AND REPORTS VOLTAGE "24 VOLTS"	
3.	"THROTTLE CHECK"	PILOT CHECKS FULL TRAVEL, CLOSES THROTTLE, OPENS TO FLIGHT IDLE POSITION (LEFT HAND) AND CONFIRMS "THROTTLE CHECK"	
4.	"FUEL SWITCH TO FUEL"	TURNS SWITCH ON AND CHECKS TO CONFIRM FUEL BOOST LIGHTS GO OFF AND RESPONDS "FUEL"	
5.	"MASTER CAUTION AND RPM WARNING LIGHTS CHECK"	PILOT CHECKS FOR LIGHTS ON AND RESPONDS "CHECK"	
6.	"CAUTION PANEL LIGHTS TEST AND RESET"	PILOT TESTS AND RESETS LIGHTS AND RESPONDS "CHECK"	

TASK	GUNNER SAYS:	PILOT	TIME
7.	"FIRE DETECTOR TEST SWITCH-TEST"	PILOT FLIPS SWITCH UP AND CONFIRMS FIRE LITE GOES ON, RELEASES SWITCH AND CONFIRMS LIGHTS GOES OUT AND SAYS "CHECK"	
8.	"ALTIMETER SET" AND ROTATES HIS KNOB TO FIELD ELEVATION	PILOT ROTATES KNOB TO FIELD ELEVATION AND SAYS "CHECK"	
9.	"FIRE GUARD POSTED"	PILOT CHECKS TO SEE IF FIRE GUARD IS IN POSITION AND SAYS "CHECK"	
10.	"ROTOR BLADES"	PILOT INSPECTS TO ENSURE BLADES ARE AT 90^{o}, UNTIED AND CLEAR AND SAYS "CLEAR"	
11.	"ENGINE START"	SIMULTANEOUSLY PRESSES STARTER SWITCH AND HOLDS (LEFT HAND) AND STARTS TIMER (RIGHT HAND); HOLDS COLLECTIVE DOWN AND CENTERS CYCLIC; MONITORS VOLTAGE INCREASE, CLOCK, N1 AND TGT ALTERNATELY; LISTENS FOR UNUSUAL ENGINE SOUNDS; RELEASES STARTER SWITCH AT EITHER 40% N1 OR 35 SECS; TURNS OFF IGNITION KEY AT 750^{o}C TGT; TURNS ON IGNITION SWITCH AT STABLE TGT	
12.	"GENERATOR SWITCH-ON"	PILOT TURNS GENERATOR SWITCH ON, NOTES AMMETER INDICATION, AND CONFIRMS DC GEN LIGHT GOES OUT AND SAYS "ON"	

TASK	GUNNER SAYS:	PILOT	TIME
13.	"BATTERY SWITCH-RUN"	PILOT TURNS BATTERY SWITCH TO RUN POSITION AND SAYS "CHECK"	
14.	"ENGINE AND TRANSMISSION OIL PRESSURE-CHECK"	PILOT ENSURES GAUGES WITHIN LIMITS AND SAYS "CHECK"	
15.	"THROTTLE IDLE"	PILOT TURNS THROTTLE UP TO IDLE AND SAYS "IDLE"	
16.	"N1-CHECK"	PILOT ENSURES N1 IS BETWEEN 68-72% WHILE HOLDING THROTTLE AT IDLE STOP AND SAYS "CHECK"	
	ENGINE RUNUP		
17.	"CAUTION LIGHTS-CHECK"	PILOT CONFIRMS ALL LIGHTS OUT EXCEPT ALTER AND RECTIFIER AND SAYS "CHECK"	
18.	"AMMETER-CHECK"	PILOT CONFIRMS LESS THAN 200 AMP READING AND SAYS "CHECK"	
19.	"AVIONICS-AS DESIRED" AND TURNS ON VHF RADIO	PILOT TURNS ON FM RADIO, RADAR ALTIMETER TO "ON", ADF TO "ON", VHF TO "ON", VOR TO "ON" AND TRANSPONDER TO "STANDBY" AND SAYS "AVIONICS ON"	
20.	"SCASS POWER SWITCH-POWER"	PILOT TURNS SWITCH TO "POWER" AND MONITORS IF SCASS NO-GO LIGHTS GO ON AND EXTINGUISH BY 50 SECS	
21.	"CANOPY DOORS-SECURE" AND SECURES HIS DOOR	PILOT SECURES HIS DOOR AND SAYS "SECURE"	

TASK	GUNNER SAYS:	PILOT	TIME
22.	"ENGINE AND TRANSMISSION INSTRUMENTS-CHECK"	PILOT CHECKS INSTRUMENTS AND SAYS "CHECK"	
23.	"THROTTLE-FULL OPEN"	PILOT SLOWLY INCREASES THROTTLE TO 100% RPM AND MONITORS TGT AND TORQUE	
24.	"ALTERNATOR SWITCH-ON"	PILOT TURNS ALTNR SWITCH ON AND CONFIRMS ALTNR AND RECT LIGHTS OUT AND SAYS "CHECK"	
25.	"ENGINE DE-ICE"	PILOT TURNS DE-ICE SWITCH ON, MONITORS SLIGHT TGT INCREASE, MOVES DE-ICE SWITCH TO OFF AND MONITORS TGT DECRESE AND SAYS "CHECK"	
26.	"SCAS" AND LOCATES HIS FINGER ON SCAS RELEASE SWITCH AND INSPECTS BLADES FOR ABNORMALITY DURING PILOT INDUCED CHECKS	PILOT CHECKS THAT HE'S CLEAR AROUND A/C AND THAT SCAS LIGHTS ARE OUT; LOCATES FINGER ON SCASS RELEASE SWITCH; ENGAGES PITCH, ROLL AND YAW CHANNELS ONE-AT-A-TIME AND INSPECTS BLADES FOR ABNORMALITIES: TELLS GUNNER TO BREAK SCASS	
	GUNNER PRESSES SCAS RELEASE		
		RE-ENGAGE SCAS DISENGAGES SCAS RE-ENGAGES SCAS	
27.	"ALTIMETERS"	RESETS ALTIMETER AND SAYS "CHECK"	

TASK	GUNNER SAYS:	PILOT	TIME
28.	"HSI" AND ANNOUNCES STANDBY COMPASS HEADING	PILOT SETS HSI TO MATCH STANDBY COMPASS HEADING	
		BEFORE TAKE-OFF CHECK	
29.	"RPM"	CHECKS TO ENSURE 100% AND SAYS "100%"	
30.	"SYSTEMS"	CHECKS ENGINE, TRANSMISSION, ELECTRICAL AND FUEL SYSTEMS INDICATORS AND SAYS "CHECK"	
31.	"ARMAMENT SYSTEMS"	CHECKS ARMAMENT SYSTEMS ARE ON-LINE AND FUNCTION PROPERLY AND SAYS "AS REQUIRED"	
32.	"TRANSPONDER"	SETS TRANSPONDER AND SAYS "AS REQUIRED"	
		PICK UP TO HOVER	
33.		PILOT INCREASES COLLECTIVE, PEDALS AS NECESSARY TO MAINTAIN HEADING, CYCLIC AS NECESSARY TO MAINTAIN ALTITUDE	
		HOVER CHECK	
34.	"FLIGHT CONTROLS"	CHECKS FLIGHT CONTROLS FOR PROPER POSITION AND RESPONSES AND ANNOUNCES "CHECK"	
35.	"ENGINE AND TRANS-MISSION INSTRUMENTS"	CHECKS INDICATORS AND SAYS "CHECK"	

TASK	GUNNER SAYS:	PILOT	TIME
36.	"FLIGHT INSTRUMENTS"	PILOT CHECKS: AIR SPEED, ADI, VSI (UVI), SLIP INDICATOR, HSI, AND SAYS "CHECK"	
37.	"POWER"	PILOT CHECKS IF POWER AVAILABLE COMPARES WITH PREDICTED VALUE FROM CHARTS (PPC) AND SAYS "CHECK"	

Mission: Attack

Mission Segment: Fire Suppression

Helicopter: AH-1s (ECAS) (N=4)

TASK	GUNNER	TIME	PILOT	TIME
1.			DETECTS TRACERS DIRECTED AT LEAD SHIP	
2.			RADIOS LEAD SHIP "LEAD TAKING FIRE FROM 7 O'CLOCK"	
3.			TELLS GUNNER TO AQUIRE TARGET - "GUNNER-TARGET!" AND MAINTAINS HSS (HELMET SIGHT SYSTEM) ON TARGET	
4.	VERIFIES TOW CONTROL PANEL SWITCHED TO "TSU/GUNS" AND PUSHES ATS (ACQUIRE-TRACK-STOW) SWITCH TO "ACQUIRE," CAUSING TSU (TELESCOPIC SIGHT UNIT) TO SLEW TO PILOT-DESIGNATED LOCATION		CHECKS OR PLACES SWITCHES INTO PROPER POSITIONS: - MASTER ARM SWITCH TURNED TO "ARM" - WEAPONS CONTROL SWITCH TURNED TO "GUNNER"	
5.	PRESSES ACTION BAR WHILE LOOKING INTO TSU		MAINTAINS ORIENTATION	

TASK	GUNNER	TIME	PILOT	TIME
6.	IDENTIFIES TARGET, MANEUVERS JOYSTICK TO PUT CROSSHAIRS ON TARGET AND SQUEEZES TRIGGER		MAINTAINS ORIENTATION AND APPROACH	
7.			PULLS AWAY FROM TARGET	
8.	RAISES HEAD FROM TSU AND PLACES ATS SWITCH TO "STOW"			

TIME = 15-20 SECONDS (N=1)

Mission: Attack

Mission Segment: Pop Up and TOW Launch

Helicopter: AH-1s (ECAS) (N=4)

TASK	GUNNER	TIME	PILOT	TIME
1.	SEARCHES MAP FOR REPORTED TARGET LOCATION AND FORMULATES EXPECTANCY OF GEOGRAPHIC LAYOUT		ORIENTS AIRCRAFT TO HEADING GIVEN BY SCOUT	
2.	CHECKS OR PLACES SWITCHES INTO PROPER POSITIONS: - TCP (TOW CONTROL PANEL) MODE SWITCH IS SET TO EITHER "MAN" OR "AUTO" AND THUS ARMED - TCP "MISSILE SELECT" IS SHOWING AN AVAILABLE MISSILE - ATS SWITCH (ACQUIRE, TRACK, STOW) ON SIGHT HAND CONTROL PANEL IS SET TO "TRK" - MAGNIFICATION SWITCH ON LEFT HAND GRIP IS SET TO "LO"		CHECKS OR PLACES SWITCHES INTO PROPER POSITIONS: - MASTER ARM SWITCH TURNED TO "ARM" - WPN CONT SWITCH TURNED TO "GUNNER"	
3.	CONFIRMS "TOW'S READY"	10	ASKS GUNNER "IS TOW "READY"	10

TASK	GUNNER	TIME	PILOT	TIME
4.	VERIFIES POWER AND TGT ARE WITHIN LIMITS BEFORE CLEARING TREE TOPS		INCREASES COLLECTIVE PITCH TO UNMASK THE AIRCRAFT IN PRESCRIBED DIRECTION	
5.	REMOVES M 24 MASK			
6.	PLACES RIGHT HAND ON TRACKING JOYSTICK AND PLACES HEAD IN TSU		ACQUIRES TARGET AND INCREASES COLLECTIVE UNTIL LINE OF SIGHT OF TSU ACHIEVED	
7.	SEARCHES FOR TARGET WHILE SLEWING TSU WITH JOYSTICK		MONITORS PSI ("PILOT STEERING INDICATOR") TO KEEP IN CONSTRAINTS	
8.	DETECTS, AND RECOGNIZES TARGET AND PLACES AND MAINTAINS CROSSHAIRS ON TARGET			
9.	SWITCHES MAGNIFICATION ON LEFT HAND GRIP TO "HIGH"			
10.	PRESSES "ACTION" BAR ADJUSTS CROSSHAIRS AND TELLS PILOT "READY"	10		10
11.			PILOT ENSURES A/C IS IN CONSTRAINTS AND TELLS GUNNER "READY"	
12.	LAUNCHES MISSILE ON LEFT HAND GRIP AND MAINTAINS CROSSHAIRS	10	MAINTAINS A/C IN CON-STRAINTS; INSPECTS POWER, TORQUE, TGT	10

TASK	GUNNER	TIME	PILOT	TIME
13.	AFTER IMPACT, LEAVES TSU, AND PRESSES WIRE CUT BOTTON	23	INITIATES DESCENT	23

=43
=30
=43

=39
N=3

APPENDIX D

RATING SCALES FOR HELICOPTER TASK TAXONOMY

Example Scale
(from Fleishman and Quaintance, 1984, p. 482)

This dimension considers the amount of muscular effort required to perform the task. Examine the task and identify the most physically strenuous part of it. Rate this part on the scale below.

Definitions	Scale	Examples
	7	
High amount of muscular effort-response(s) require a high degree of muscular involvement.		• Do 40 push-ups • Lift the heaviest weight possible.
	6	
Moderate amount of muscular effort required for the response(s).		• Tighten nuts on bolts securely with a wrench.
	5	
	4	
	3	
	2	
Low amount of muscular effort required		• Solder two wires together. • Add numbers and report the sum aloud.
	1	

Rater #1. Helicopter Task Characteristics Ratings

TASKS \ RATING SCALES	NUMBER OF OUTPUT UNITS	DURATION OUTPUT UNIT MAINTAINED	NUMBER OF ELEMENTS PER OUTPUT UNIT	WORKLOAD	DIFFICULTY OF GOAL ATTAINMENT	PRECISION OF RESPONSES	RESPONSE RATE	SIMULTANEITY OF RESPONSES	DEGREE OF MUSCULAR EFFORT INVOLVED	NUMBER OF PROCEDURAL STEPS	DEPENDENCY OF PROCEDURAL STEPS	ADHERENCE TO PROCEDURES	PROCEDURAL COMPLEXITY	VARIABILITY OF STIMULUS LOCATION	STIMULUS OR STIMULUS COMPLEX DURATION	REGULARITY OF STIMULUS OCCURRENCE	OPERATOR CONTROL OF THE STIMULUS	OPERATOR CONTROL OF THE RESPONSE	REACTION TIME/FEEDBACK LAG RELATIONSHIP	FEEDBACK	DECISION MAKING
TAKE-OFF TO HOVER	1	5	4	2	2	4	3	6	3	7	6	6	6	5	7	3	6	7	2	5	6
HOVER POWER CHECK	1	1	3	2	2	4	3	5	3	5	5	5	3	7	7	3	5	7	4	6	5
CARGO HOOK-UP	4	1	4	3	4	7	2	7	4	6	7	6	5	6	7	4	5	6	3	6	4
DEPART WITH CARGO	1	1	3	1	2	5	4	5	3	5	6	5	4	5	7	4	6	6	3	5	5
CARGO DROP-OFF	4	1	3	2	3	6	3	6	4	5	6	6	5	5	7	4	6	6	3	6	4
DEPART	1	1	3	1	2	5	4	5	3	5	6	5	4	5	7	4	6	6	3	5	5
LOW-LEVEL NAVIGATION	4	6	5	6	3	5	5	6	4	6	5	5	5	5	7	5	6	5	2	5	6
EVADE THREAT	1	1	3	4	7	4	6	7	5	4	6	7	3	1	6	1	1	7	5	6	2
ENGINE FIRE	1	1	3	4	3	6	6	7	5	4	7	7	3	7	7	1	1	7	5	6	2
FIRE SUPPRESSION	3	3	3	2	4	5	6	6	5	4	5	5	3	1	4	3	1	7	5	6	3
TARGET HAND-OFF	4	4	4	3	4	5	4	7	4	6	4	5	4	3	6	4	4	7	3	5	6
POP-UP & TOW LAUNCH	4	4	4	3	5	7	5	7	5	7	7	7	6	4	7	4	3	7	3	6	5
RUNNING LANDING	1	1	3	3	2	6	3	6	3	6	6	6	5	6	7	3	6	7	2	5	6

Rater #2. Helicopter Task Characteristics Ratings

TASKS \ RATING SCALES	NUMBER OF OUTPUT UNITS	DURATION OUTPUT UNIT MAINTAINED	NUMBER OF ELEMENTS PER OUTPUT UNIT	WORKLOAD	DIFFICULY OF GOAL ATTAINMENT	PRECISION OF RESPONSES	RESPONSE RATE	SIMULTANEITY OF RESPONSES	DEGREE OF MUSCULAR EFFORT INVOLVED	NUMBER OF PROCEDURAL STEPS	DEPENDENCY OF PROCEDURAL STEPS	ADHERENCE TO PROCEDURES	PROCEDURAL COMPLEXITY	VARIABILITY OF STIMULUS LOCATION	STIMULUS OR STIMULUS COMPLEX DURATION	REGULARITY OF STIMULUS OCCURRENCE	OPERATOR CONTROL OF THE STIMULUS	OPERATOR CONTROL OF THE RESPONSE	REACTION TIME/FEEDBACK LAG RELATIONSHIP	FEEDBACK	DECISION MAKING
TAKE-OFF TO HOVER	3	1	7	2	2	4	7	7	3	7	7	7	5	5	7	6	6	3	4	6	1
HOVER POWER CHECK	4	1	7	4	2	4	7	7	1	7	7	7	5	6	7	6	4	4	3	5	7
CARGO HOOK-UP	1	5	7	6	5	7	7	7	4	3	5	5	6	6	7	7	1	7	4	4	3
DEPART WITH CARGO	1	1	1	1	2	2	7	7	2	2	3	5	2	6	7	7	6	7	5	6	3
CARGO DROP-OFF	1	4	5	5	3	5	7	7	2	3	5	5	4	3	7	7	6	7	5	7	3
DEPART	1	1	1	1	2	2	7	7	1	2	7	3	2	6	7	7	6	7	4	7	2
LOW-LEVEL NAVIGATION	4	1	2	4	5	6	7	7	1	1	2	3	7	2	7	6	1	7	2	5	6
EVADE THREAT	1	4	2	7	6	5	7	7	2	3	5	4	5	1	4	2	1	1	3	6	6
ENGINE FIRE	4	5	7	7	6	7	7	7	6	7	7	7	7	2	4	1	1	1	6	4	4
FIRE SUPPRESSION	4	3	2	7	5	7	5	7	2	2	2	2	2	2	4	2	1	5	5	5	5
TARGET HAND-OFF	2	2	4	3	3	6	2	7	2	4	4	4	3	2	6	4	1	6	6	3	3
POP-UP & TOW LAUNCH	1	6	5	7	7	7	7	7	3	7	7	7	7	1	7	3	1	2	4	6	3
RUNNING LANDING	1	2	2	2	2	3	7	7	2	4	4	4	4	5	7	7	4	7	4	7	3

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